Variable Oxygen- or Nitrogen-Enriched Air System for Combustion Engines

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Problem/Opportunity

Cold-starting a gasoline engine results in significant hydrocarbon, carbon monoxide, and air toxics emissions; diesel engines release particulates and smoke; air toxic emissions are produced over time when burning alcohol fuels; and natural gas engines reduce emissions but have lower power density. These problems can be solved, to some degree, through variable air composition. Researchers have demonstrated that nitrogen oxide emissions can be reduced by exhaust recirculation in both gasoline and diesel engines. However, only a limited amount of exhaust can be recirculated without reducing power output and fuel economy. Recirculated soot particles may also cause wear in diesel engines.

Argonne Solution

Argonne is developing a simple process that uses low-cost permeable membranes to separate ambient air into oxygen- and nitrogen-rich streams. The membrane, about the size of an air filter, supplies a stream rich in oxygen to improve combustion or in nitrogen for exhaust post-treatment.

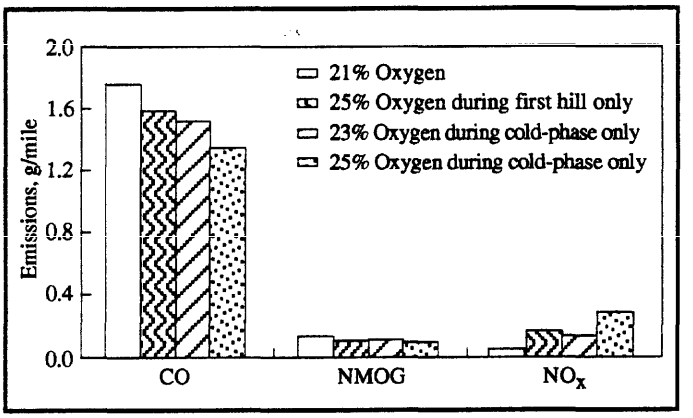
Advantages/Benefits

Increasing the oxygen flow to the engine offers the following benefits:

- In diesel engines, reduces particulate emissions and increases engine power output.
- In gasoline engines, reduces emissions during cold starts to meet EPA's Tier II emissions standards (year 2004).
- Increases the power density of vehicles powered by natural gas and reduces emissions from alcohol fuel vehicles to meet ULEV standards for formaldehyde and nitrogen oxide emissions.
- Allows the use of lower-grade fuels in diesel engines.

Increasing the nitrogen flow to the engine offers other advantages:

- In diesel-fueled vehicles, potentially reduces nitrogen oxide emissions without the problems caused by exhaust gas recirculation (engine wear, oil contamination).



Potential of oxygen-enriched intake air to meet 2004 standards.

- Eliminates the need for a heat exchanger to cool exhaust gases before recirculation.
- Can be used to generate monatomic nitrogen plasma that chemically reduces nitrogen oxide and nitrogen dioxide from both gasoline- and diesel-powered engines.

Technical Concept

Air can be enriched in oxygen or nitrogen by selective permeation through nonporous polymer membranes, the "solution diffusion" mechanism. The process is technically simple, and the equipment compact and modular. A single air separator membrane provides both oxygen- and nitrogen-rich streams so that the nitrogen-to-oxygen ratio can be varied for either combustion or exhaust treatment applications.

Status

Argonne has filed for, or is in the process of filing for, the following patents:

- Method and Apparatus for Reducing Cold-Phase Emissions from Gasoline-Powered, Light-Duty Passenger Vehicles (ANL-IN-95-070)
- NO_x Reduction Method (ANL-IN-92-066)
- Nitrogen Spark De-NO_x-er (ANL-IN-94-133)
- Method and Apparatus for Providing Variable Oxygen-to-Nitrogen Ratio in the Air for Combustion Engine Applications (ANL-IN-95-152)

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